STRESS, FATIGUE AND THE GENERAL LINE OFFICER

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Harry Walter Kinsley, junior

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ABSTRACT

Stress and fatigue are factors of great import in the decision making process. As such they should be areas of great interest and concern to the Navy, particularly in their relationship to the decision making capabilities of unrestricted line officers. The recent writings and experimentation in stress and fatigue are analyzed to point up the importance of these phenomena as they affect the unrestricted line officer, to examine the methods which the Navy might utilize in measuring and prediction, and to show applications which might be attempted in the areas of alleviation and control. The destroyer commanding officer is the criterion against which the stress and fatigue are measured. The conclusions are that fatigue and the effects of stress are, indeed, quite serious in their ramifications, that the Navy should be more cognizant of them, that positive programs can be established to reduce these effects at nominal cost, and that such programs might have valuable pay-offs in ships and lives.

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INTRODUCTION

Stress and fatigue are common factors in the lives of many people--from the most highly paid professional man to the lowliest "hired hand." No one group can claim a monopoly on these problems, although, certainly, the repercussions on people may be more marked in some cases than in others. Of the professions, very few have as much dependence on one man as the military. In the Naval branch of the military, perhaps, this relationship is most strikingly seen in the relationship to a ship's commanding officer.

This presence of stress and fatigue is not a startling revelation. It is very familiar to every officer who has served at sea. It can be observed in the actions of one's superiors, in the actions of one's contemporaries, and, most important, in one's own actions. It is perhaps most graphically demonstrated by Herman Wouk in his great novel, The Caine Mutiny. A part of the wide appeal of this work to the professional Naval officer lies in the "tragic hero" quality of Captain Queeg. Queeg, to the Naval officer, is an experienced seaman who has been a "successful" commanding officer--albeit with some undesirable characteristics. It seems reasonable to assume, however, that many of Queeg's more acute idiosyncrasies were brought to the fore by undue stress. It is difficult to believe that Queeg could have performed "successfully" so long, had he not kept those tendencies submerged through appropriate psychological defense mechanisms. Queeg, in retrospect, becomes a character whom the Naval officer can understand, and with whom he can, to some extent, identify. We have each lived some of Queeg's experiences; there may be something of Queeg in each of us.

All of us have seen the results of stress and fatigue--sometimes in lapses, sometimes in errors of judgment. Unfortunately, in some cases

the harvest of the stress and the fatigue has been death--not only for individuals, but for ships and crews as well. This paper is an attempt to shed some light on stress and fatigue, in the firm belief that the more known about an "enemy", the better the battle can be waged.

As a destroyer sailor, I have very keen interest in the subject matter of this report. In the light of long experience as a subordinate officer in these ships, it is important to understand the forces impinging on the leader. In the light of possible future assignments as a commanding officer, it is important to assess oneself. (Parenthetically, it is made a matter of record here, that in every instance in the body of this report where I recommend that a prospective commanding officer be subjected to tests or examinations or "trial by fire", I stand prepared to participate as a "subject".) Whatever the individual cost, the Navy must have highest standards in command-at-sea positions. One important command criterion is explored in this paper--the ability to resist stress.

This report is respectfully dedicated to the destroyers of the Navy in the hope that the information contained herein may help the officers who run these ships to be more effective. More specifically it is dedicated to the destroyers with which I have been directly associated through the courtesy of the Bureau of Naval Personnel:

USS Brownson (DD 868)
Raymond (DE 341)
Blair (DER 147)
Coolbaugh (DE 217)
Greenwood (DE 679)
Barton (DD 722)
Soley (DD 707)
John R. Pierce (DD 753)
Wren (DD 568)
Richard E. Kraus (DD 849)
Borie (DD 704)
Wallace L. Lind (DD 703)

USS Hank (DD 702)
English (DD 696)
Henry W. Tucker (DD 875)

Monterey, California

June, 1964

CHAPTER I

THE PROBLEM

The purpose of this study is to review the recent research on the effects of stress and fatigue on decision making, with specific attention to those studies which relate to the decision making problems of U. S. Naval officers of the unrestricted line, in an attempt to show that some of the conclusions of this research should be of great interest and concern throughout the Naval Service, and that certain specific actions by the Navy are both desirable, and easily implemented.

In determining which studies to review, the writer has applied a subjective criterion of relationship to command-at-sea. This subjective criterion was necessitated by the fact that there was insufficient material available on the subject of Naval decision making to conduct a study. Therefore, the writer has selected research studies and collected data about groups, which, in his opinion, could be brought to bear on the problems confronting the unrestricted line officer decision maker. The criterion of command-at-sea has been selected since this is the traditional "yard-stick" for judging the unrestricted line officer--the sine qua non of the profession. Recognizing that command-at-sea presents different problems with ships of different size and capabilities, and that commanding officers differ in degrees of maturity and experience, the writer has restricted his analysis to the decision making problems encountered in destroyers. There were three principal reasons for this choice: the experience of the author, the "small group" atmosphere found in destroyers, and the wide range of types of destroyer operational functions. Of the three reasons, the consideration of writer's experience is undoubtedly the least important. Since, however, most of the writer's

Naval experience has been in destroyers--over eight years-- it proved convenient, and permitted comparisons based on rather extensive first-hand experience. The other two reasons, however, seem significant enough of themselves, to justify the choice.

The "small group" atmosphere is extremely important. In destroyers, all officers meet each other, formally or informally, at least daily, and usually more often; furthermore, they frequently discuss common ship's problems and proposed solutions openly. Since there are seldom more than fifteen officers attached, most officers are assigned multiple duties and there is considerable overlapping of organized boards and committees, in addition to the traditional, formal, departmental structure. Quite frequently, this creates a sort of "family" atmosphere which is almost totally lacking in larger ships. While a destroyer commanding officer may "confide" in his subordinates no more of his thoughts by percentage than a large ship commanding officer does, because the number of "confidants" is considerably less, the absolute quantity of dependence on and confidence in particular subordinates is much greater. Additionally, several other factors about destroyer living tend to create group interaction. For one, living quarters are cramped, especially in the older ships, and there is usually only one space where two or more officers can meet officially or socially during their off-duty hours--the wardroom. For another, all officers, including the captain, usually dine together in the wardroom mess. (On larger ships, the commanding officer usually dines in his own mess; in destroyers, this procedure is followed infrequently.) This factor, alone, almost guarantees conversation and the cross-pollination of ideas. Third, the personnel turnover in destroyers is extensive, with the experienced junior officers being replaced by the new or inexperienced, which means that the commanding and executive officers must continually

attempt to close this "experience gap" with positive training programs and well directed counsel. As a result of factors such as these, destroyer officers usually form tightly knit groups, with a keen, common understanding of the general problems that face the commanding officer as well as the specific ones for which they as individual officers bear personal responsibility.

The wide range of destroyer capabilities needs very little explanation. Destroyers, today, function in anti-submarine warfare and detection both with shipborne equipment and through equipment carried in helicopters which are launched, controlled and recovered by these destroyers; they participate in anti-air warfare as platforms carrying long range detection equipment, sophisticated missile and gunfire control systems, with weapons capable of considerable concentrated and destructive firepower against land and surface as well as air targets. Destroyers have a wide capability in electronic warfare, countermeasures, and for early warning of air attack. In addition, destroyers provide many less dramatic non-combatant services, such as in search and rescue operations, life guard services for ships undergoing underway replenishment, rescue destroyer services for air operations, support for Antarctic operations, and counting the population in the Trust Territories. Furthermore, destroyers are often called upon to "pinch hit" in duties normally assigned to other types--towing at sea, fueling other ships, evacuation of personnel, weather and meteorological operations. Such a wide spectrum of operations provides a broad base for viewing the problems of Naval decision making.

The most important "definition" of this paper is the writer's conception of the role of the commanding officer of a destroyer in decision making. This can be divided into several "key" areas. The most obvious of these is that of the structure and organization of the ship, itself. As in all military organizations, the basic structure is authoritarian. Almost

all external information affecting the command filters in through the commanding officer, and almost all information leaving the command bears his stamp of approval, either actual or implied. Most of the shipboard decision making process is influenced by his interpretations, his personality, and his capabilities. While individual personality differences in amounts of authoritarianism may result in personal variations in command behavior, all direct orders are authoritarian, and every commanding officer must issue them. Furthermore, custom and tradition hold that the commanding officer is not only legally responsible for all actions undertaken by and in the name of his ship, but is morally accountable as well.

A second consideration in command-at-sea is isolation. At sea, a ship is separated from the military environment, and freed from many of the constraints of the military hierarchy. The immediate environment and the formal chain of command do affect the decisions of the commanding officer, but minimally. More often, it is a case of "out of sight, out of mind." Beyond the limits of the ship, very little if known of how the job is being done; the only observable thing is whether the job is being done. Isolated operations mean that the commanding officer has no superior to direct him in difficult decisions; it often means that he has no one with whom to discuss difficult orders and problems. In sum, it means that in a ship at sea the commanding officer has unquestioned and absolute responsibility and authority in all matters affecting the ship, for sustained periods of time.

In addition to these factors, which apply generally to all commands at sea, there are certain factors which apply specifically to destroyers. In a destroyer, for example, the commanding officer frequently finds a low level of experience among his subordinate officers. Oftentimes, he finds that the executive officer is the only other officer embarked who has served in another ship. Frequently, unfortunately, the executive officer is so enmeshed in the administration of the ship and in the collateral duty of navigation, that he is not available to assist the commanding

officer on key decisions--especially, if time precludes "briefing" him to "fill him in." This considerably constrains many commanding officers, for even if they would prefer to delegate responsibility, they often find that the capabilities that their subordinates possess are not adequate to cope with complex problems. This situation creates a dilemma so common that it might be termed the "commanding officer syndrome"--whether the decision can be delayed long enough to permit subordinate officers the opportunity to prepare recommendations properly, and gain valuable experience, or to forego this training because an immediate or an expedient decision is required. The commanding officer, alone, must weigh the relative worth of the training against the necessary checks and cross-checks required, and decide. Typical of decisions of this type is that which confronts the commanding officer each time he brings the ship alongside the pier, or alongside another ship. It might be slower to permit an inexperienced officer to make the approach; it might be more hazardous to the paintwork and the stanchions; it might be embarrassing to the commanding officer if the landing is a bad job, and an important reporting senior is observing. An approach, still, is of negligible value to the subordinate, if the commanding officer, himself, performs it; the "learning is in the doing." The commanding officer must subjectively examine the alternatives, and decide. In all these decisions, he must consider the relative inexperience of his subordinates; he must acquire an accurate first-hand knowledge of their capabilities and shortcomings. He must know how much he can delegate to each, and whether he can trust their individual recommendations or not.

One of the greatest difficulties encountered in the preparation of this paper has been to establish workable definitions of two basic technical terms--"stress", and "fatigue." Both terms are widely used in many different ways. The most useful meaning of "stress", for purposes of

this report, follows closely the teaching of Hans Selye, the noted physiologist.[1] It is somewhat amusing that the most felicitous expression of the phenomenon, in the opinion of the writer, was located in a basic psychology text--Clifford T. Morgan's Introduction to Psychology. Morgan states:

> Most of us are sometimes exposed to unusual stresses. When we must go too long without sleep, when we suffer burns, or protracted pain, when we are exposed to extreme cold or extreme heat, or when we work much too long at tiring and exacting tasks, we are stressing our bodies because such extreme conditions demand more of our bodies than they can normally bear.[2]

Selye, moreover, provides a very useful concept to define the critical relationship between "stress" and "fatigue"--the "general adaptation syndrome." In essence, this concept states that the reaction to stress occurs in three stages--"alarm reaction", "resistance to stress", and "exhaustion".[3] For the purposes of this study, interest centers around the third stage, for the terms "exhaustion" and "fatigue" seem very nearly approximate. In the light of this "general adaptation syndrome" approach, after some sort of emotional outburst marking the initial surprise, the individual settles down and attempts to withstand the stress as best he can, which ultimately results in his exhaustion.

Unfortunately, the term "fatigue" cannot be dismissed simply as a degree of exhaustion. Part of the quandary rises from the fact that, until recently, no one had succeeded in measuring fatigue accurately, or in accurately defining what they were measuring. As a result, the whole topic of "fatigue" is fuzzy and ambiguous, with a considerable amount of overlap in the connotations and denotations assigned by various "experts". This dilemma is well expressed by Arthur Gilbert Bills, writing for Encyclopaedia Brittanica:

> The term is used ambiguously, sometimes referring to the organic state of exhaustion or lowered energy following work; sometimes to the feelings of tiredness or boredom experienced at such times, and often to the decline in efficiency of performance during a continuous work session.[4]

Another facet of this ambiguity can be seen in an excerpt from an article by A. T. Welford, one of the great contributors to fatigue research:

> To the "man in the street" it means a subjective state, following or regarded as following (it may anticipate) some kind of physical or mental stress. It is not easy to specify precisely. To the physiologist, it means some kind of reduction of response following more or less prolonged activity-- the "mechanism" in some way becomes insensitive or inert . . . The psychologist occupies a position between the two.[5]

In the same article, Welford describes three types of "fatigue effect"--"simple performance decrement", "disorganization of performance", and "cumulative disruption of performance", and alludes to a fourth factor which he calls the "onset of fatigue and change of method". He also indicates that "fatigue effects" are transferrable--that fatigue associated with one task may affect another. The same author uses "fatigue" to mean both effect and cause! Other writers have been more definite in their stand. Dill, for example, concluded that fatigue was caused by stress, either of a physical origin, such as inter-personal friction between business associates, and that it was a temporary disturbance of equilibrium which may be primarily physiological, as in depletion of energy reserves, or psychological, as in frustration.[6] Other attempts to clarify fatigue have included trying to delineate various types of fatigue by "causation" categories. Podolsky, for example, adopted the categories "muscular", "emotional", "environmental", and "metabolic". These terms are all self-explanatory except "emotional", which

Podolsky defines as the "chronic" fatigue frequently caused by frustration, depression, worry, or fear of the unknown.[7] Such categorization is of great interest to the physiologists and to the medical profession, because it separates the measurable from the unmeasurable--the "treatable" from the "untreatable". It is not so useful to the psychologist. The psychologists, moreover, seem to lack this simplicity and directness. Fraser, another prolific contributor, provides a particularly illuminating illustration:

> In the first phase, fatigue tends to affect high grade performance long before there are signs of physiological exhaustion. The more complex the performance, the more delicate the discriminations, the greater the number of sources of information which have to be attended to, the more likely the performance is to suffer from fatigue. There is not necessarily a gross falling off in performance, or extensive errors, or long patches of bad work. Rather we find at first the occasional slip, the momentary confusion of two similar signals, the slight pause in the smooth rhythm of skilled performance . . . Secondly, it seems to be now well established that performance where knowledge of performance is small is likely to be most sensitive to fatigue. . . The results obtained . . . suggest that it is very misleading to consider fatigue as a single and simple phenomenon which builds up in the same way under different conditions in different types of activity and requiring different methods of study and measurement.[8]

In the ensuing chapters of this report, the term "fatigue" will be used in its meaning as an effect of stress. The question whether stress produces fatigue which in turn produces further effects is beyond the scope of this report. In this paper, furthermore, the term "fatigue effects" will not be used, since, as defined herein, these should be termed "stress effects".

It is the belief of the writer that the area of stress and fatigue is one which should be of great interest and concern to the Navy Department. Lapses in judgment, irrational acts, hasty and imprudent decisions

are deleterious when merely the well-being of one individual decision maker is involved, but they can become disastrous when they are considered in a command situation. It is easy to hypothesize that stress and fatigue are intimately connected with marine disaster of all types; it is difficult to prove, because it is difficult to assign definite causes in such cases, and because, in the most serious of disasters, the "evidence" and the witnesses, unfortunately, frequently perish. It is the contention of the writer that in command-at-sea, the psychological makeup of the individual in command is critical, and the type of decision which he must make is critical. It is the belief of the writer that psychological and physiological stress testing are far enough advanced and of sufficient validity that such testing of all line officers on a regular basis should be accomplished, and the results utilized when officers are considered for command-at-sea. Furthermore, it is the belief of the writer that the gravity of fatigue is such that all officers who are in a position where their decisions might affect the welfare of others should be made cognizant of these consequences of stress.

In the preparation for this paper, over 900 abstracts of articles, experiments, and books related to stress and fatigue have been reviewed by the writer. From this group, nearly 200 were gleaned for closer examination, after determination by the writer that these studies treated with matters which, in some way, were related to those types of fatigue which might be experienced by a destroyer commanding officer. From these studies were selected most of the material for this report. Since these studies do not treat specifically with Naval officers' fatigue, the actual value of the research is limited. In the opinion of the writer, however, if the study shows that decision makers who are exposed to stresses and experience fatigues like those encountered by Naval officers, do suffer certain effects, and if the study shows that these effects can be measured and predicted, the study will have served its purpose. Such a study as

this cannot be conclusive; reaction to stress is different for individuals, and different for the same individual by situation or occasion. A study such as this, however, might provoke the specific, detailed, specialized research required to support the analogies drawn herein. If this purpose is served, the paper is successful; if, however, it does nothing more than to convince one "doubter" of the need not to underestimate the magnitude and the seriousness of fatigue, the time expended is well used.

Additionally, background reading and research have been conducted in the areas of "stress" and "fatigue". The results of this reading were rather disappointing; the "general" psychologists have devoted precious little space to the subjects; the "general" physiologists have done somewhat better, but even their coverage seems wanting. Furthermore, much of the physiologists' work completely ignores the mental and emotional aspects. The various journals have proven, consequently, to be the major source of information, and it is the opinion of the writer, for this reason, that the method of review utilized provided the best and most comprehensive examination of material possible within the parameters of time and resources. It is recognized that having to use the translations of studies as provided in the abstracts, as well as the difficulties of using incomplete data when the studies were not available, may result in compounding the "error of transmission. It is the opinion of the writer that this is a matter of little import to the study, however, since most of the items of interest are considered in broad rather than specific context.

One of the most interesting things about fatigue research is that it is being pursued at the present time by scholars of two related yet different disciplines--physiology and psychology--from divergent points of view. While both groups accept the concept of a general relationship between fatigue and stress, the physiologists are concerned more with measuring effects, while the psychologists are considering causes. Since cause and effect are inexorably linked, it seems somewhat parochial to

attempt to separate them. Recognition of this fact has caused some writers to attempt to approach the problem from a middle ground of "psycho-physiology".[9] For this report, however, the approach is largely psychological, since this is the concern of the writer. This is a necessary limitation because of constraints in time and space, as well as in comprehension of the writer.

In organization, the ensuing study has been divided into three functional categories. In each category, the findings are reviewed and related to the command-at-sea base. There are obvious limitations to this type of analysis. The most serious is that the categories overlap; consequently, some studies included in one section spill over into others. Another drawback is the factor of time. Frequently, there is a time lag of two or more years between the appearance of articles in the respective journals and the publication of the abstracts. Furthermore, this time lag is not constant, for some articles, especially those written by the abstracters themselves, often appear soon after their initial publication. As a result of this, it is very hard to gauge interrelationship of knowledge in the studies. Some studies are obviously read soon after initial publication; others are not seen until several years later when they are abstracted. There are, in addition, international complications to such interrelationships analyses, since it is impossible to ascertain the influence of research published in Yugoslavia on that published in Germany, or France, or Japan, and no one knows what the Russians are doing. Doubtless, with translations available, abstracts rendered into English may be influential to American research, but it is often impossible, even among studies originated within this country to estimate <u>quantity</u> of influence.

In the three subsequent chapters, the three functional areas of the stress-fatigue research will be discussed. These are "effects","measurement and prediction", and "alleviation and control". These categories

are not mutually exclusive; they overlap and are interdependent. A knowledge of effects is necessary for measurement; measurement is necessary to evaluate alleviation; alleviation is meaningless without the effects. Generally, however the distinction has been relatively easy to make. There has been considerable research in each area in recent years--much of which is of considerable import in a command-at-sea situation.

FOOTNOTES

[1]Hans Selye, The Physiology and Pathology of Exposure to Stress (Montreal: Acta, Inc., 1950), 822 pp. Psychological Abstracts, 1951, 25:2788.

[2]Clifford T. Morgan, Introduction to Psychology (New York: McGraw-Hill Book Company, Inc., 1956), 676 pp., p. 567.

[3]Morgan, op. cit., pp. 567-568.

[4]Arthur Gilbert Bills, "Fatigue," Encyclopaedia Britannica (Chicago: Encyclopaedia Britannica, Inc., 1963), IX, p. 112.

[5]A. T. Welford, "The psychologist's problem in measuring fatigue," Symposium on Fatigue, W. F. Floyd and A. T. Welford, (eds.), (London: H. R. Lewis and Co., 1953), 196 pp., pp. 183-191.

[6]David B. Dill, "The nature of fatigue," Geriatrics, 10:474-478, 1955. Psychological Abstracts, 1956, 30:5363.

[7]E. Podolsky, "Managing fatigue," Military Surgeon, 107: 380-384, 1950. Psychological Abstracts, 1951, 25:4697.

[8]D. C. Fraser, "Recent experimental work in the study of fatigue," Studies in Personnel and Industrial Psychology, E. A. Fleishman, (ed.), (Homewood, Illinois: The Dorsey Press, 1961), 633 pp., pp. 473-478.

[9]Chester W. Darrow and Charles E. Henry, "Psychophysiology of stress," A Survey Report on Human Factors in Undersea Warfare (Washington: National Research Council, Committee on Undersea Warfare, Panel on Psychology and Physiology, 1949), 541 pp., pp. 417-439. Psychological Abstracts, 1951, 25:3569

CHAPTER II

THE EFFECTS OF STRESS

It seems appropriate to commence a study of stress and fatigue with an analysis of the "effects" area. In this field, the quantity and diversification of the research can best be observed. The quantity of material needs no further comment; the diversification aspect is worthy of some little expansion. The reader can not help but be impressed by the numerous categories into which the several writers have divided fatigue. At times, it seems almost as if they intentionally describe new categories, rather than attempt to adapt their research to the terms of others. This has the effect of artificially inflating both the quantity and the diversification; it is a characteristic well to keep in mind, although it will not be developed further in this report. Even with this limitation, it is safe to say that the study of effects does provide a reasonable idea of the overall enormity of the area of fatigue.

Perhaps the most valuable distinction in the "effects" area, is the difference between "subjective" fatigue--how tired the individual feels--and "objective" fatigue -- to what measurable degree his ability to perform has been diminished. In 1953, Gugenheim conducted a study utilizing students performing a monotonous task requiring little physical exertion, in which he attempted to compare the two phenomena.[1] His findings are very enlightening; he found that amount and quality of work have little correlation with feelings of fatigue. He also found that irregularity of performance may accompany the feeling of fatigue. In conclusion, he inferred that "subjective" and "objective" fatigue were, in fact, very little related. This finding is of significance for two very different reasons. First, it shows very clearly the problem of measurement; "objective" fatigue can not be self-measured in a simple fashion. Second, and much more serious, the individual may be deceived because he feels

exhausted when he, in actuality, is not, or, even worse, he feels fine when he is, in fact, debilitated.

An interesting study by Walker provides a somewhat more encouraging slant on the problem.[2] He considered that activity which does not involve strenuous physical exertion may be continued for long periods of time without appreciable deterioration of performance. Walker's list of requirements for positive results are quite illuminating, and might well be applied in an alleviatory program. One such requirement is "good" working conditions. This, of course, is something over which the destroyer commanding officer has no original control, since he does not design his ship. There is, however, much that he can do to maintain the best possible working conditions within the parameters set by the physical characteristics of the "plant." Some of the other aspects pointed up by Walker are very closely related to motivation. Walker suggests that an individual should have personally established and self-accepted standards of performance, and that he should consider any deviations from these standards as personal failure. Walker emphasizes the importance of keeping the individual continually informed of how well he is meeting the standards. Shipboard standards for performance are easily established; acceptance constitutes no problem. The last statement is the one which all in command would do well to heed; repeated experience bears out the fact that performance is markedly higher when continuous knowledge of how well standards are being met is provided. This may not always be possible; it provides a worthwhile goal.

More recently, Ramsay has conducted a study which deals with another aspect of this problem.[3] He was greatly concerned that individuals feel tired and run down without exerting themselves, and at other times expend a considerable amount of energy without tiring. He performed a study examining the onset of fatigue in situations in which muscles were minimally impaired. In this experiment, he established and defined three non-energistic variables--intensity of need to do well, apparent

distance in time and energy to the goal, and knowledge of appropriate "mediating" behavior. He found that the need factor did not offset speed, but that it did affect reported tiredness--the lower the need, the more tired the subject. He found a high correlation between bad performance and reported tiredness. He concluded that the work situation systematically affects the individual's subjective state. In this context, morale and motivation take on considerable added luster.

A later study by Pearson contradicts some of these earlier findings.[4] In a study in which he examined 100 subjects on a complex fatiguing, perceptual motor task against a 73 item validated check list, he found that feelings prior to the test performance, and the performance, itself, were not necessarily related, and that measures recorded during the performance indicate that feelings do not necessarily parallel the performance. Exactly how much "subjective" fatigue is related to performance seems to vary with personal characteristics of individuals, with peculiarities of the test situation, with the characteristics of the task, and with the motivation. It remains fuzzy, and presents a great number of unexplored interstices for future researchers.

Some of the most fascinating of studies of effects have been performed in the broad area of "visual" fatigue. This incidentally, is an area which may include fatigue of the eye, muscular or nervous, emotional fatigue, mental fatigue, central nervous system fatigue, and probably several others, depending on the author. It is an interesting area for a number of reasons. For one, the importance of sight in living has caused disproportionate research in this area; for another, the problems of "eyestrain" and "eye headache" are commonly experienced, and uniformly noisome. Visual fatigue is a problem on board ship, as it is in all environments involving both close and distant work, as well as considerable visual vigilance.

Many contributions of value have been made in the area of visual fatigue--some specific and narrow in application, some broad and general. An example of the narrow is a study conducted by Leonard Carmichael on reading and visual work.[5] He discovered that over six hour periods, in some cases, there was no appreciable eye fatigue. He attributed this to a specific mobilization of energy which offsets the fatigue. Furthermore, he suggested that high motivation of the individual was definitely involved, since the less well motivated subjects were the ones that showed impairment. Visual fatigue is important to the destroyer commanding officer, not only because of the familiar and traditional requirements of the bridge, but also because of the less widely publicized problems of administrative work which oftentimes seem to be interminable. More important than this limited point about visual fatigue, however, is the consideration that high motivation may affect other fatigue as well. If this is true it may provide a positive reason for carrying out strong morale-building programs.

The broad approach can be seen in a very valuable and thorough study recently published by H. C. Weston.[6] In this article, not only does he explain in depth the physiological causes of "visual" fatigue, he also clearly defines the phenomenon, and, in so doing, makes possible some semblance of control. Weston accomplishes this by eliminating visual boredom and the drowsiness caused by inadequate lighting from his definition; he concentrates his attention, therefore, on that factor which is <u>self-controlled</u>--the "weariness resulting from the bodily and mental exertion of seeing." This definition has other interesting aspects; Weston clearly recognizes that visual acuity may be impaired both by the physical stress on muscles other than ocular muscles, and by mental stress. This illustrates quite graphically the interrelationship of stresses. In <u>one</u> individual <u>several</u> stressors may each cause the same discrete amount of fatigue! Weston also found a

correlation between motivation and fatigue which is most enlightening:

> Usually not more than half of the cycle duration is spent in fatigue inducing vision. These studies refer to good lighting. Under adverse conditions more of the visual activity may be unproductive, or more productive of mistakes, but there may be no greater total expenditure of energy than there is under conditions of lighting which allow this energy to be expended more productively. Most people energize at their maximum only occasionally and, as has already been stated, under strong motivation. Habitually, they work well within their physiological capacity and, by taking suitable "rest pauses"--either spontaneously, whenever a feeling of fatigue arises, or involuntarily-- they avoid undue fatigue. This is just as true of working with the eyes as with other workable parts of the body.[7]

The significance of this to the destroyer commanding officer is two-fold; he must understand the relationship of the eyes to total fatigue, and he should appreciate the benefits of good lighting.

Another aspect of eye fatigue of particular interest to a destroyer commanding officer is seen in recent research into the ocular fatigue of radar operators. While commanding officers probably will not spend prolonged periods examining radar scopes, they all use them, and oftentimes during those periods of bad weather and poor visibility when other stressors are exerting their influences, these scopes receive their heaviest use. A study published in 1953 by Riffe burgh points up the seriousness of the problem.[8] Disturbed by the disproportionate number of reports of tiring and headaches among radar operators, he performed a detailed study in the area. As a result, he noted that these effects were not caused by physiological features such as ocular muscle imbalance or refractive error, but, rather, were the function of several variables, the more important of which were the posture of the operator, the rate of the radar sweep, the relative brightness of the surrounding room, and the length of time that the operator was on duty. As a result of his experiments, he recommended no more than one half hour per

sitting at the "gear", and the use of red goggles when leaving the room to lessen discomfort. These findings are not world-shaking; they are well known throughout the Navy at all levels from command to operator. The point is that the recommended procedures are not followed, and perhaps the rhetorical question which should be posed is whether the man on board ship who can least afford to suffer fatigue can continually afford himself the luxury of failing to heed the recommendations.

Another aspect of the research into effects concerns the general relationship of heat to fatigue. Undoubtedly, this was of much greater import to destroyer commanding officers before the widespread installation of air-conditioning in ships. It is worthwhile noting, however, that there remain a great many destroyers which are not air-conditioned, and, unfortunately, no way has yet been devised to guarantee that the air-conditioning will not suffer casualties.

A very thorough treatment of many aspects of this problem is contained in a 1953 article by F. P. Ellis, a doctor in the Royal Navy.[9] In this treatise, he probes what he terms "tropical" fatigue--the mixture of physical fatigue, which shows up in reduced hard work, mental work, as evidenced by increased lassitude, and nervous fatigue, as shown by irritability and pettishness, which are considered characteristics of life in the tropic zone. In this paper, he, very precisely, lists all the major contributory factors: hot climate, inertia or boredom, monotony, isolation, "racial stress" caused by not understanding native customs, traditions, and language, "domestic stress" caused by separation from family,"social stress" caused by excessive social activities, conditions of service, or discontent due to differences in pay, especially among service personnel, overwork, cultural deficiencies such as lack of good libraries and music, improper clothing, insects, and ill health. Ellis readily admits that many of these factors are not unique to the tropics but he considers that life in the tropics tends to produce an aggregate, different and more serious

from that found in other climes. One of the best parts of Ellis' presentation is his whimsical "mathematical" summation:

> This brief review of some possible causes of "tropical" fatigue indicates that most of the factors involved are by no means characteristic of the tropical zone. Fatigue does not arise at the higher altitudes, in the hill stations where an equable climate is attainable, where many tropical towns are built, and where the ancient tropical civilizations were centred [centered]. The hot climate is the common denominator in the warm humid coastal regions where tropical fatigue does occur, but it is not always the most important cause, and generally when serious neurotic or psychotic states supervene, it is not the most damaging factor. Then patterns such as the following can be visualized:
>
> hot climate alone (e.g. warship's company in the tropics),
>
> hot climate + inertia + domestic stress (housewife's fatigue),
>
> hot climate + monotony, perhaps + alcohol (as a result of long-term residence),
>
> hot climate + isolation + operational fatigue + domestic worries + insects + adverse service conditions (troops engaged in tropical warfare),
>
> hot climate + overwork + social stress, perhaps + alcohol (government or service officials in large centres [centers]),
>
> hot climate + monotony + domestic stress + isolation + insects + cultural deficiencies (isolated tropical communities).[10]

What the proper equation for an American destroyer would be is not important; it would differ in quantity and quality from ship to ship. The important thing to recognize is that a similar equation does exist.

Another important aspect of the research into effects has been the concern with the general problem area of monotony. This is of particular interest to the destroyer commanding officer because the incidence of monotony aboard ship is not as infrequent or sporadic as is sometimes believed. Perhaps this can best be seen in missions such as waiting for an astronaut to land, or on an ocean station lying under the track of an aircraft carrying a President, or in "lying to" on station as part

of an early warning line, or in a long drawn out area search where the same pattern is repeated over and over again. The fact is that during certain periods, destroyer duty can be monotonous, and while this is certainly not the usual case, it cannot be disregarded.

An interesting study in this area was prepared by Welford, Brown, and Gabb.[11] They found that the performance of civilian air crews in problem solving was poorest immediately after a long flight, and depended on whether the duties were hard or light. Those with harder duties seemed to suffer more fatigue from a combination of loss of sleep, higher stress, and monotony, than those with less arduous duties. This seems highly significant for a destroyer commanding officer, because while his duties are never light, he frequently finds himself working under a combination of stresses. Oftentimes monotony is not as readily controlled as other stresses since the reasons for its existence are beyond the capabilities of its victims to contain in a suitable manner. A destroyer commanding officer, for example, might dispense with monotony by holding five inch anti-aircraft "burst" practice while the Presidential plane was in the area, but this would not be very suitable. Monotony is most dangerous in combination with other stressors; it can make a bad situation worse. It should not be underestimated.

An area of considerable concern and interest to the destroyer commanding officer in the field of "effects", is the area of combat stress, and its resultant "battle fatigue". Some purists may argue that this is not truly "fatigue"--contending that it is a psychological reaction. No attempt will be made to decide this question in this report. "Battle fatigue" is of considerable significance to a destroyer commanding officer whatever its origins may be; for this reason it is considered properly included in this paper. It is interesting to note that most of the studies performed in this

area have been with Army personnel as subjects, and, as a result, these findings must be used with caution. Some of those which seem to have some significance are included hereinafter.

Frederick Hanson has prepared one such study.[12] He concerned himself with the relationship between fatigue and what he termed "combat neuroses". He concluded that physical fatigue does not cause "combat neuroses", but that it does debilitate the individual, and lower his resistance to the emotional stress of combat. Furthermore, he hypothesized that, as a result, a change in amount of physical fatigue will change the amount of resistance to emotional stress available to the individual. Frequently, the commanding officer can not get the proper amount of rest to restore him from the effects of physiological stress. He should force himself to rest physically when he has the opportunity, in order to insure himself as much resistance to emotional stress as possible.

Another highly interesting area to commanding officers is the question of age and resistance to stress. The commanding officer, of course, has been traditionally dubbed the "old man", and whether he cares to admit it or not, he often is the oldest man aboard a destroyer. At best, the destroyer commanding officer, in age bracket 35-45, is considerably older that most of the crew. Bearing this in mind, the findings of Brill, Beebe, and Loewenstein seem especially significant.[13] In a detailed analysis of the incidence of psychoneurosis among white enlisted men, they found it, surprisingly, to be a function of age, and of military environment. The initial shock of this finding demands a closer look into the background of the experiment. This study concerned Army enlisted men in 1944, a "population" which might at best be called "involuntary" soldiers. Secondly, the results showed that psychoneurosis increased with age among personnel of an unselected army population, among personnel stationed in the continental United States, and among an unselected population overseas, but that there was no evidence to support such a conclusion for the personnel

of a regimental combat team. It seems that there are three points to take from this study. The first is that high motivation may counteract the effects of stress as evidenced in other of the research in stress and fatigue; the second is that aging may produce lower thresholds to stress; finally, and most important of all, motivations may vary, and, consequently, ability to resist stress may change. The ability to withstand stress in a newly commissioned officer of 21 may be greater or less than that of the same officer when he takes command of a destroyer at age 40, depending on many factors which were completely unpredictable at age 21; it is a statistical certainty that his ability to withstand stress will not be exactly the same, yet is this not what is assumed when officers receive psychological testing before commissioning, and are not retested? This, alone, seems to provide a good reason for a retesting program.

Another type of effect of great import to the destroyer commanding officer is that caused by psychological stresses. Again, as in the case of battle stress, there might be some disagreement among purists regarding the legitimacy of including such material in this treatise. Since these effects, however, bear on the same decision maker who may be combating fatigue caused by another stressor, they seem quite properly included in this study, and are.

A good study in this area was published by Kohn in 1954.[14] In a pair of experiments conducted using three variables--threat of an electric shock, distracting conditions, and "ordinary" conditions--he found that the irrelevant parts of a detailed picture were forgotten rather than the relevant ones. This indicated that perception and performance under mild psychological stress suffer very little--a fact which is of considerable significance, for it suggests that under emotional stress, a decision maker will not "lose the big picture," and should be able to continue to function as an effective commander.

In another interesting experiment conducted in India, Rao used two groups of delinquent boys as subjects in an inquiry into the effects of psychological stress on rigidity in problem solving.[15] One group was frustrated and punished during the experiment; the second group served as control. Rao found that, for the most part, the experimental group showed more errors in problem solving, and especially more perseverative errors. Certainly, a destroyer commanding officer is not a delinquent Indian boy; there are many situations, nevertheless, when he suffers frustration and rebuke. Unfortunately, many of these are such that rigidity might prove disastrous. An example might better emphasize the point. A destroyer commanding officer is called to the bridge at dawn to find that his ship has been directed to change station in a screen. Before he can properly acclimatize himself, a signal is received from the O.T C. directing him to expedite taking station. Upset because the officer of the deck has been very slow in taking action, and not very well rested from a night of reports from previous O.O.D.'s, the captain turns to the O.O.D., and says, "Let me see your maneuvering board." The O.O.D. hands the captain the relative plot, but neglects to tell him that "own ship" is in the center; the captain always plots the guide in the center. The captain assumes the "conn," gives the incorrect course order to the helm, puts the speed up to 25 knots, and then discovers he is going the wrong way! While this example may sound contrived, it is not; it closely approximates an experience observed by the writer. Reaction to stress and rigidity in problem solving may be a rather dangerous mix.

Another study in the area of psychological stress, written by Shepard, is of considerable interest because it "debunked" a familiar idea about ulcers, and stated a valuable and workable preventative measure.[16] In a 1954 study about stress disorders written from the standpoint of an industrial physician, he hypothesized that stress disorders, such as neurosis, arthritis, ulcer, and coronary disease were usually attributed

to the "strain" of the occupation, but that this was not the true cause of difficulty. Rather, he stated that the causal factor was imbalance between stresses of the occupation and the worker's tolerance, based on his own peculiar physical and mental characteristics. He pointed out, furthermore, that a physician was best able to make the determination of this factor, and he advocated periodic physical and psychological exams to do it.

Wolff, in a 1954 study, made an interesting contribution to the work on a psychological stress.[17] He believed that in addition to stresses from the physical environment, a man reacted to threats and symbols from his past. He also indicated that cultural and individual damages were unpredictable and might be more harmful than the actual occurrence itself. It seems worthwhile mentioning that a Naval officer's "past" does not terminate the day he enters the service; it is dynamic and, at best, is only a microsecond old at any given point in time. It might be well to examine it periodically, in conjunction with psychological tests, and to keep it "on file" in its most recent form.

No study of effects would be complete without mention of physical effects. This is an extremely important area of fatigue research, and is one in which a great quantity of work has been done. It is of secondary importance to this paper, however, because the hard physical exertion such as that experienced by an athlete running a race, or of a steel worker stoking an open-hearth furnace, are physical stresses which most destroyer commanding officers will not approximate in the line of duty. Furthermore, a large preponderance of the "physical" studies are written from a metabolic or a physiological point of view, and for purposes of this study these findings are of interest only in the quest for finding accurate and sensitive measures for fatigue. On the other hand, no commanding officer can afford to dismiss this subject of physical fatigue completely. A short passage from a 1953 study by Hemingway illustrates this

well.[18] In describing an experiment concerned with physical exercise and blood flow, he stated:

> Within the limits imposed by the experiment, the blood flow during the exercise was not necessarily proportional to the amount of work being done. The mechanical hindrance of the contractions reduced the flow during exercise to 40 percent of what it would otherwise have been. It seems obvious that in such circumstances fatigue will ensue earlier than would otherwise be the case, and this finding may be the explanation of why exercise such as "push-ups" and "chin-ups" fatigue the muscles so rapidly.[19]

Since commanding officers under 40 are required to perform "push-ups" and "chin-ups", it seems important to recognize this relationship to blood circulation. It also seems important to note that in the paragraph following the one cited above, Hemingway showed the relationship between circulation and cardiac output during exercise. Infrequent "push-ups" and "chin-ups" can create a fatal stress.

A considerable amount of research has been done in the area of the relationship between noise and fatigue. While many destroyer decisions are made in the silence of a quiet bridge, it may be necessary to make critical decisions to the accompaniment of booming guns or with blaring radio equipment obligato. Helper published an interesting study on the subject in 1957.[20] He measured fatigue, during the performance of a mental task in quiet, while not performing the mental task under conditions of 110 decibels of noise, and while performing the task under additional stress from the 110 decibel noise, and found that the noise itself was relatively non-stressful, but it added to the physiological "cost" of mental work, although it did not affect overall task performances. Significantly, he noted no correlation between physiological reactions to noise and effects of noise on performance.

In another 1957 study, Jerison and Wing examined the effects of noise on a task requiring close vigilance and attention.[21] Alternating two hour periods between noisy and quiet, they found that performance

under close vigilance suffers with noise, and that the quiet period showed no reduction in proficiency. It is encouraging to note that the Navy tradition of a quiet bridge makes good psychological as well as intuitive sense.

A very worthwhile study on the effects of noise has been prepared by Broadbent and Little.[22] In this article the authors provide a very succinct summary of the noise problem:

> The effect of the noise is to increase the frequency of momentary lapses in efficiency rather than to produce decline in rate of work, gross failures of coordination or similar inefficiency. Effects have never been shown with noises of less than 90 db (above the usual arbitrary level of .0002 dynes/sq. cm.). In view of the rather specific nature of the effect found in the laboratory, it remained a doubtful question whether this effect of noise is of any practical importance. Furthermore, no matter how prolonged the laboratory experiments, they cannot hope to involve people who are accustomed to noise as they would be in a real life situation. For this reason it has become very desirable to check the results of the laboratory experiments in an actual working environment.[23]

The results of this industrial experiment indicated that rate of work was not improved by noise reduction, except by improving overall morale. It did show, however, that human error was less frequent when the noise level was lower.

In a recent study, Corcoran brings out another very interesting aspect of the research on noise.[24] In two experiments in which he examined human performance under the stress of 90 decibel white noise and loss of sleep separately and in combination, he found that noise was effective in reducing the deterioration of performance characterized by loss of sleep. In this case the effects of the stressors cancelled each other somewhat! This series of experiments points up one very interesting aspect of the total research in the area; at different times, different stressors produce different reactions on different individuals. Sometimes the stressors cancel each other and the resultant is lesser

fatigue than might be expected by merely summing; sometimes the stressors complement each other and produce the full amount; there is some contention, even, that stressors in combination may produce even more than this sum because of interaction of stresses. Withal, the time, situation, and individual psychological make-up become of increasing import.

Probably the most dramatic of all research into effects in terms of results accomplished has been the work on sleep deprivation. Coincidentally, this may be the most common single stressor that a destroyer commanding officer encounters. Long arduous operations demanding his attention as a decision maker, incessant calls during the night to interrupt what are often fretful attempts at sleep, in addition to whatever psychological stressors may be affecting him at the time, can easily combine to deny him sleep for protracted periods

One very important concept that this experimentation has brought out is the fact that individual reactions to this type of stress are extremely different. This was made very clear in a 1956 study by Seymour.[25] Examining subjects under the stress of sleep deprivation of 60 hours duration, he made five significant conclusions. First, he noted that the deviant behavior of the subjects as well as the test patterns were highly individual. Next, he noted that the personality and emotional life of individuals were more greatly affected by stress than psycho-physiological factors. Third, he observed that those individuals who evidenced pathological signs at the peak of the stressful situation did not have different test patterns. Next, he noted that the individuals who demonstrated pathological tendencies on individual testing either through self evaluation or from pathogenic test results, showed no different test patterns during or at the height of the stress. Finally, he observed that individuals with erratic behavior during the course of the experiment did not show different test patterns. From these findings, Seymour concluded that fatigue and impairment were

strongly influenced by the entire organization of the individual, including his long-range ideas, goals, and self-evaluation. It certainly seems that this provides cogent testimony for the continual psychological evaluation of Navy decision makers.

Another interesting study in the area of sleep deprivation concerned an experiment performed by Pepler.[26] In an experiment in which he examined 12 subjects on a pursuit tracking task for 30 minutes, and on a serial choice task for the following 20 minutes under conditions combining the variables of normal and high temperature, and normal rest and one night sleep deprivation, he found that the effect of temperature was qualitatively different from that of lack of sleep. He based this on the observation that under sleep deprivation the subjects omitted responses on the serial choice test, and failed to correct misalignments in the tracking, but in warmth, they continued to respond to both tasks, although their proficiency was not as great as it was under normal temperature conditions.

Williams, Lubin, and Goodnow also made an interesting contribution.[27] They conducted two studies with 49 subjects under the stress of 72-98 hours of sleep loss. Comparing performance on tasks on which the experimenter set the pace with those on which the subject set the pace, they found that the number of errors was greater in experimenter-paced tasks. Transferring these results to the destroyer situation, the fact comes to mind that the most critical of decisions undertaken during conditions of sleep deprivation are seldom "subject" paced. When the commanding officer is called to the bridge at two o'clock in the morning, he often has to unravel a knotty problem right then, and make a positive decision without equivocation. Frequently, he has no margin for error, as well.

In another experiment in this field, Wilkinson investigated the effect of lack of sleep on visual watchkeeping.[28] He compared individuals' performance after a "normal" night's sleep with their performances after being

deprived of one night's sleep, on a forty minute test of visual watchkeeping. He noted three kinds of errors, signals missed while watching the display, signals missed while not watching the display, and signals missed while asleep, and observed that a lack of sleep produced an increase in all three. He also commented that the forty minute test had to be prolonged before the results indicated that moderate sleep loss produced a deteriorated performance. This suggests one of the most dangerous concepts about sleep deprivation; it has curvilinear effects. There is little deterioration of performance over a long period of time--24 hours-- and then there is a decline in performance which accelerates. It is obvious that it would be a most valuable piece of information to know one's "threshold", but it changes with time, location, and the effects of other stressors. It is difficult to quantify outside the laboratory.

Morris and Singer also conducted an experiment recently of some considerable interest.[29] They divided a group of 74 enlisted men into groups of 5 or 6, and studied them under the effects of 72-98 hours of sleep deprivation through tests given before and during the experience, and interviews concurrently conducted. They observed that the subjective experiences reported, and the defenses used were in line with individual personality factors, but also were influenced by the behavior and attitudes of the staff and of other subjects in the group. Of these, however, they found that the most significant factor in behavior under conditions of sleep deprivation was individual personality.

One of the most fascinating things about the study of "effects" is the discovery of interrelationships. A recent Wilkinson study provides a case in point.[30] In observing a group of subjects deprived of sleep, he found that, on a task of prolonged addition, when the subjects were not told how they were doing, the sleep deprived produced adverse results, but when they were kept informed of how they were doing, the adverse effects diminished. More significantly, he found a relationship between muscle tension and

resistance to sleep deprivation. He found that of the subjects deprived of sleep, the ones whose performance had been least impaired had the most muscle tension. Those who demonstrated the greatest falling off in performance on the test experienced relatively little muscle tension. Wilkinson concluded that sleep deprivation in this amount produced these two results, and that they were substitutable one for the other.

The major and most dramatic work in sleep deprivation, however, has been in the results of the longer experiments, and the relationship to mental disorder. Three studies illustrate this aspect particularly well. In the first of these, Bliss, Clark, and West kept 7 medical students awake for 72 hours, and 4 awake for 48 hours after receiving LSD 25, a drug with ego disruptive effects.[37] They found minimal changes on psychological tests, but indications of subjective personality alterations in all. They also found that feelings of depersonalization, illusions, hallucinations, disturbance in time perception, and differences in auditory acuity were prevalent. They found that sleep deprivation enhanced the effects of the LSD 25. They concluded that sleep deprivation might have a pathogenic potential, especially when combined with other psychological processes, and that prolonged wakefulness might be a critical factor in the precipitation of some schizophrenic illnesses.

In the second study, Luby, Grissell, Frohman, Lees, Cohen, and Gottleib kept twelve paid volunteer males awake for 123 hours.[32] They noted in progression, attention lapses, visual changes from double vision to illusions to hallucinations, with irritability followed by overt hostility. They also noted a resistance to the hallucinations at first, followed by a general acceptance as a paranoid system became stabilized. They also noted significant changes in biochemistry, a fact which may hold some significance for future work.

In the third study in this area, West, Janszen, Boyd, and Cornelisoon made a very interesting report on sleep deprivation as a psychosis.[33] Their conclusions are strong enough to make any rational person pause and consider for a long time before stressing his body by prolonged sleep deprivation. They

concluded that the point of psychosis occurs somewhere after 100-120 hours of sleeplessness. They spoke of two phases to the process. In the first, a progressively increasing drowsiness occurred with some brief lapses of awareness. Fine movement was replaced by gross tremor. The senses were disturbed and illusions were experienced. Vigilance decreased, and there was a noticeable increase in oral activity and what the authors called "pre-psychotic phenomena." In the second phase, a full blown psychosis appeared. They noted that the process could be stopped by a period of 12-15 hours sleep, during which the subject experienced much vivid dreaming, but that impairment of some functions lasted up to 10 days.

Many more studies of effects have been conducted and published. Those cited hereinbefore, however, give some idea of the magnitude and the breadth of the research area, and of some of the pitfalls encountered. Some writers have concentrated in attempting to enclose the entire area with ideas. Such an idea was developed by Muller and Worchel in a 1956 study.[34] They concluded that the individual who considered himself slightly inadequate was usually more efficient than either the one who considered himself highly adequate or the one who considered himself highly inadequate, when ability to perform under stress was measured. This seems a very useful point for self-evaluation. Another finding which may have even broader significance when applied is propounded by Zaida.[35] He hypothesized that under conditions of conflict or frustration that the human organism would ultimately suffer disorganization of behavior which might be transitory or might be permanent -- depending on the intensity of the stimulus and the capacity of the exposed organism. More important, he stated that intelligence might be one of the critical conditions of reaction to stress. This result is underscored by another study, which was conducted by Lazarus and Eriksen.[36] In an experiment utilizing a Wechsler-Bellevue digit symbol subtest, they found that subjects with high academic standing improved under stress, and that those with low academic standing did rather poorly, and were more variable in performance.

For many years, we have taken Wellington's famous words that the "battle of Waterloo was won on the playing fields of Eton," as gospel. Perhaps, it might be that the battles of today and tomorrow will be won in the classroom.[37] At any rate, many and varied are the effects of stress; many and varied are the fatigues and the impairments which a decision maker may suffer. So serious are the effects, that the problems of measurement and prediction must be "tackled" in order to attempt to prescribe some measure of alleviation and control. These are the problems addressed in the ensuing chapters.

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CHAPTER III

MEASURING AND PREDICTING THE EFFECTS

The second major research area is that of measuring and predicting the effects of stress. This is a complex field, largely because of the many varied effects which may be measured, and because of the many different reasons for measuring them. Some of the measures required, for example, are for the purpose of showing that fatigue or impairment has occurred, and of establishing relative measurements which indicate degree. Others are to provide an objective method for measuring propensity for fatigue so that predictions may be made by skilled observers. Unfortunately, what may be the most important measure of all has proven elusive-- providing the individual with a reliable method for estimating his own personal state of fatigue. This is a most important aspect of the "measurement" problem because, as the study of "effects" has shown, reactions to stress vary greatly from individual to individual, from situation to situation, and from time to time. Laboratory equipment, procedures, and environment are not available in the "field"-- the operational environment of the "real" world. Providing accurate self-measurement and prediction is a fertile area for future research.

The measurement of fatigue is usually divided into three types-- physiological, subjective, and objective.[1] The physiological method consists of examining various physical criteria to determine whether fatigue or impairment has occurred. This is of academic and scientific interest, but is of little use for practical prediction unless the "yardstick" developed can serve as an accurate measure in a laboratory experiment, which in turn can be used as a valid predictor of true individual reaction to stress. The subjective method consists of the individual, himself, marking down or otherwise indicating how he feels. It seems apocryphal to add that this is the only known way of measuring individual

feelings, but it is possible that in the future some more accurate measure may be developed. The objective method consists of the examination of the individual by means of various tests, and comparing the results with each other or some standard. Each of these methods will be examined in this chapter. Before proceeding with this task, however, it is important to insert one parenthetical remark about the general topic of measurment. There seems to be a great amount of "negative" research in this area--demonstrating, for example, that particular methods of measuring are not valid or reliable. This is explained by the fact that it oftentimes is very worthwhile to know that a particular measure which has been widely accepted, is, in fact, not an effective measure. Faulty measures produce erratic results.

There are two common physiological methods of measuring fatigue which have been in more or less continual use over the past 15 years.[2] One of these, which employs the "ergograph" is used to measure "physical" fatigue. In this method, the extent of specific muscle pull (usually of the finger muscle), against a known weight, is recorded continually until exhaustion is reached. The other method, a phenomenon known as "critical flicker fusion" is used to measure "mental" as well as "physical" fatigue. In this method, a disc consisting of alternating black and white sectors, is rotated before an observer until it appears gray. The speed at which this phenomenon occurs is lower when fatigue is greater. A 1952 study by Pieron indicated the value of this method of measuring.[3] He showed that flicker fusion not only was sensitive enough to measure "physical" and "mental" fatigue, it also could measure the fatigue resulting from sleeplessness, and could show the recovery caused by an ingestion of caffeine on a sleep-deprived subject.

By far the more useful of these two measuring methods from the standpoint of this study is the flicker fusion phenomenon. Some of the applications and limitations developed are worthy of note. For example, Brožek,

Simonson, and Taylor provided an important restriction to its use.[4] After conducting a study in which they examined fitness under various types of strain--such as strenuous visual work under varying illumination, library and laboratory work under moderate stress, various activities under nutritional stresses such as starvation or prolonged semi-starvation, and thiamine deficiencies--and activities under severe stresses--such as sleep deprivation for two nights, hard physical work, hot environment--they concluded that fusion level could not serve as an accurate measure of the degree of involvement of the central nervous system for biological stresses of the type applied.

Another interesting note about flicker fusion was divulged in a 1955 study by Davis.[5] In using visual flicker fusion and auditory flutter fusion, a comparable phenomenon, to measure the worsening of performance after two hours of mental arithmetic, he found that both showed traces of declination in performance. More important, however, after one hour, he noted decrement in the auditory measure, and none in the visual one, causing him to conclude that auditory flutter fusion may provide a more sensitive and convenient fatigue index than visual flicker fusion.

A very fascinating attempt to find an accurate measure was recounted in a study by Ryan.[6] Measuring fatigue caused by excessive glare while the subjects were performing a simple task, he attempted to utilize muscular potentials measured at the tibialis anterior of the leg, the triceps muscle of the "inactive" arm, the two ear lobes, and the trapezius at the base of the neck on the "inactive" side. (The "inactive" arm represented the left arm in the case of a right-handed individual, and right for left-handed.) He found that muscle tension was a significant measuring device, but was not as fine a differentiator as visual flicker fusion. He hypothesized that muscular tension, flicker fusion, and auditory flutter

were all related to the broad function of the central nervous system, and so could be valid measuring methods for various types of fatigue.

There have been a multitude of other indicators developed in the physiological area. Some seem quite obvious; others seem so remote that an observer wonders whatever caused the scientists involved to "discover" them. Sung-Ken Quo, for example, found that in the application of a specially constructed hammering device to the knees of 160 strenuous mental workers, he had an accurate and simple method of measuring mental fatigue which was reliable, both in the daytime and the nighttime, and, at the same time, measured a gradual rise as the working hour proceeded.[7] Another measurement technique was employed successfully by Loewenstein and Lowenfeld.[8] They recorded eye pupillary reactions before and after work to show individual differences in fatigue, and used "pupillograms" to present their findings. In a 1953 study, a group of seven doctors studied air navigators at rest and after a long flight, tried a variety of tests, and found that cardiovascular observations, and electroencephalograms provided useful methods for measuring.[9] Still another group of measuring devices have been employed by Baker and Taylor.[10] In their study of stress effects, they found significant relationships in skin temperature differences, electrical skin resistance, and pulse rate. Their findings about skin temperature were of especial interest, because it was in opposition to the "traditional" idea that stress causes a temperature drop in the skin. Another interesting measuring method in the area of stress reaction is hippuric acid count. (Hippuric acid is more familiarly known as the major component of horse urine.) Studies such as that performed by Basowitz, Korchin, and Grinker indicated that this particular measure might be of more value as an anxiety indicator than for fatigue.[11] In light of recent research showing the "tie-in" between these two "effects", this might prove to be a very valuable, if somewhat unusual, measuring medium. Many

and varied are the measures employed, and while some are replaced by more "sophisticated" means with the passage of time, the fact remains that for the isolated phenomenon which they were designed to measure they performed well.

Most of these measures might properly be termed "biological" or "metabolic". An interesting study by Ross, Hussman, and Andrews described the investigations of some measures for anxiety and fatigue which might be termed "physical".[12] These included steadiness, body sway, body sway time score, and tapping rate. They also used the old stand-by--critical flicker fusion frequency. Their findings indicated that the best indicators of bodily fatigue in this group were hand steadiness, and body sway, and that all the others must be analyzed from trial to trial, both for errors and individual differences.

Another indicator, which was suggested by Johannes Voigt, is very difficult to fit into any category.[13] This is handwriting size. He considered that all the other commonly used performance and physiological measures were too gross, or that they were too limited, being confined to one aspect of fatigue, only. He found that the size of handwriting increased as an effect of prolonged arithmetic work, and he considered the change in size a valid indicator of fatigue in the central nervous process. He found it sensitive to the effects of rest periods, both conscious and unconscious attitudes, and other psychological functions. He found it particularly valuable in comparing the effects of various kinds of work--and in measuring the differences in susceptibility to fatigue. This is especially interesting because it effectively shows the interrelationship between the "effects" and the "measurement" areas of study; in size of handwriting, fatigue was measured by examining an effect and quantifying the results.

Not all the attempts to find adequate measures have proven successful, as indicated earlier. A study by Krkovic provides a good example of a projected measure which did not come up to expectations.[14] He examined

persons fatigued by means of a step test, by prolonged mental work, and by a sleep loss of 30 hours duration, using acuity of stereoscopic vision as his measuring criterion. He found that the criterion did show some indications, but was not sufficiently sensitive to serve as a measure of fatigue. In another study, contemporaneous with this, Vidaček examined two indicators, and found one did not perform as expected while the other did.[15] In his tests he compared arm movements and fist pressure as measures; he found that the differentiation provided by arm movements was not statistically significant, while fist pressure as measured on a mercury dynamometer was highly satisfactory.

In examining the various methods of physiological measurement from the vantage of a broad over-view, it is very difficult to make valuable generalizations concerning their relative merit in measuring fatigue as the destroyer commanding officer experiences it. Many of them require complicated apparatus and laboratory facilities for implementation; nearly all require thoroughly trained and highly skilled analysis to interpret their results. Oftentimes the individual measures are limited in that they apply to one or another of the various "fatigues", but have doubtful or untested value for others. There are, nevertheless, some situations where the physiological measures are of considerable value. One such situation is described by Davis in his study concerning stress in combat.[16] In the course of a field study of combat soldiers, he recorded reactions to physiological tests, not really intending to use them. He found, however, that the objective psychological tests which he had expected would provide the accurate means of measurement he sought, were unusable because the test conditions could not be controlled. The physiological measures, with much more gross control requirements, could be utilized, and did provide him with usable data. On the "opposite side of the coin" are the results of an extensive study by Hornstra.[17] He examined 13

different physiological measures and considered that they were all inadequate. His hypothesis was that the only feasible measure was one related to performance--some sort of a "paper and pencil" test. Bujas and Petz, in a later comparative study, reported on other aspects of the problem.[18] They found that many tests failed to detect the beginnings of fatigue at all, and some only detected fatigue near the exhaustion point. They considered that examination should be directed toward complex functions rather than simple ones as often performed in the laboratory, because they believed that fatigue of a simple function is often first observable in the disorganization of a large structural task, rather than in the physiological measure of some small partial processes. Recent studies, however, still indicate valuable uses for physiological measure. A recent study by Longo and Doll provides a case in point.[19] They concluded that muscular tension might have considerable potential value as a predictor for individual stress susceptibility. In another study, Williams, Granada, Jones, Lubin, and Armington examined two physiological measures--pulse volume and electroencephalograph frequency--as measuring agents for sleep deprivation experiments.[20] They found that both methods had merits, but that the electroencephalograph was always the better. For the future, the physiological measures should continue to have significance, especially if simple measures can be developed for measuring complex effects which can be interpreted by people in the field without costly specialized training.

If the area of "physiological" measurement has shown a wide and varied research effort, the area of "subjective" measurement has shown remarkable little. So called "fatigue scales" are available, such as those manufactured and sold by Psychometric Affiliates.[21] Their product is composed of three devices called respectively, "Industrial Subjective Fatigue and Euphoria Scales", "Retrospective Work Curve Feeling Scales", and "Mothers' Day Fatigue Scales." They are quickly

answered by subjects, who tear the margin of the scale to indicate their answers. On the "Fatigue and Euphoria Scale", the subject chooses between feelings of fatigue and pleasantness; on the other two, the subject is asked when he is most tired and answers multiple choice questions concerned with the reasons for these feelings. Retest and equivalent reliability and general norms have been developed for each scale, and are included in the "kit".

Another type of development in this area is the checklist approach. In 1956, Pearson and Byars developed such a checklist for measuring "subjective" fatigues.[22] The equivalent form reliability of this list was established at .92 and .95 for experimental and control groups respectively. Another interesting method has been employed by researcher Patricia Cain Smith.[23] In a study primarily concerned with susceptibility to monotony, she used weighted criterion questions to establish subjective feelings. A brief excerpt from the study illustrates:

> The remainder (of the questions) were further modified so that they could be used in questionnaire form, and several others that seemed relevant were added . . . . After several revisions, the questionnaires were administered to seventy-five workers, including those observed in this study . . . . The answers to the criterion questions were item-analyzed against total score, and a weighted criterion score devised.[24]

"Subjective" measurement is not far developed. Most researchers recognize the problem of the variability of human "feeling". It seems, however, that if a method can be developed for evaluating comparatively individuals' feelings, a significant breakthrough will have been achieved.

For the purposes of prediction, at the present time, the area of "objective" measurement is closest of the three to providing a useful working tool. Even in this area, however, progress has not been rapid. Part of the difficulty, undoubtedly, is caused by the hazy definition of what is to be measured. Another part of the problem is the multi-dimensional characteristics of fatigue, which help make measurement

complex. With this comes the attendant problem of which variables to isolate, since fatigue must be "broken down" into workable "pieces" for analysis. Still another difficulty is caused by the fact that fatigue changes with time. Equally significant is the wide variety of individual differences. To provide a satisfactory "objective" measure for the effects of stress is indeed a sizeable task.

One of the most important of the ways in which the "effects" can be examined objectively is in the miniature work situation. As long ago as 1950, Brožek and Monke recognized the fact that the conventional laboratory experiment examined conditions quite unlike those experienced in the "normal" everyday situation.[25] They found that the laboratory procedure was too abstract; they considered in the "real life" situation the important variables were not and could not be controlled. They believed that they found a suitable compromise solution in a miniature work situation where the "man-machine" adaptations and the effects of the physical environment could be studied. One very useful adaptation of this idea is in the realm of situational testing. In this method, the unusual problem may be examined in a known environment; the effectiveness of the decision maker in coping with the situational stresses and the complexities of the problem, provide a useful evaluation tool. In 1951, Kuhlen made the point very clearly that situational testing could be adapted to stress research.[26] He suggested, for example, that this method of testing might be used to study trends in psychological adjustment encountered as a result of aging, change in marital status, and combat experience. Many other variables might be selected; the medium seems quite flexible. That the procedure may be better understood, it is well to examine a practical study. In one such study, Voas, Bair, and Ambler examined the relationship between manifest fear in flight training, and behavior in a manifest stress situation.[27] They tested the reactions of Naval air cadets under simulated high altitude

conditions in a decompression chamber, and compared the results with data obtained in answer to questions about flying anxiety answered by students who withdrew from the training. They found that significantly more of those who later withdrew had revealed their anxiety reactions in the decompression chamber than did successful cadets. Situational testing can indicate something about failure under stress. Would it not be better to find that a potential commanding officer could not operate under stress in the safety of a shore-based laboratory, than to find out "after the fact", as a result of a board of inquiry, or some other fact-finding panel?

An extremely large portion of the "objective" research has been devoted to efforts to use the results of the Rorschach and other projective tests. Part of the reason for the large quantity of research in this area is that many of the findings have been contradictory and controversial, involving not only the considerable skepticism and suspicion which surround projective tests in general, but also some doubts regarding the validity of specific findings. In one of the early studies using Rorschach results, for example, Smith and George found that the "F" factor was a satisfactory predictor for reaction to a verbally induced stress for subjects up to age 29, but that it was unsatisfactory for older subjects.[28] Such findings as this inspire a welter of questions--most of which are unanswerable. What is so "sacred" about age 29? What is the dividing line between a satisfactory predictor and an unsatisfactory predictor? Would the Rorschach factor serve as an adequate predictor for those subjects which it predicted successfully prior to the 29th birthday, after the 29th birthday? Is there, perhaps, some factor other than age which causes the difference in results which was masked to the experimenters because of the obviousness of the age bracketing? As a result of questions such as these, many consider the Rorschach worthless; its use seems to create more new questions than answers to old.

The mixed feelings among the psychologists can best be seen, perhaps, by examining several specific studies regarding the conclusions drawn by the several authors. Eriksen, Lazarus, and Strange could find no relationship between performance under psychological stress and any of several different personality measures.[29] In addition, they could find no relationship between performance under stress and any Rorschach variable. It is of parenthetical interest that they did find that the Guilford-Martin inventory of factors and the Gamin and Bell adjustment inventory indicated that subjects who improve under stress were generally more ascendant, and tended to have more self-confidence. In another Rorschach study, Carlson and Lazarus repeated an experiment which Meyer Williams had performed at an earlier time.[30] The original study had indicated a high relationship between performance under stress and Rorschach measures of emotional and intellectual control. The authors reported that they repeated the experiment carefully using the Wechster-Bellevue Digit-Symbol test, and found no relationship whatsoever between the Rorschach results and worsening of performance under stress. The results are not all negative, however. On the positive side of the ledger is the outcome of a study by Lofchie.[31] He used the Rorschach Index of Perceptual Maturity as a predictor with some success. He found that those persons scoring higher on the Rorschach generally performed better on a psychomotor task under conditions of distraction stress than those with lower scores. In a recent comparative analysis of several projective tests, Loveland and Singer examined how well the tests determined response changes and predicted behavior under sleep deprivation.[32] Their conclusion was that the Rorschach test, alone, was sufficient to evaluate the efficiency of the subject in mental and psychomotor tasks, and to predict accurately whatever he would hallucinate under sleep deprivation. In summary, it seems as if too much emphasis has been placed on the value of Rorschach test results. There is no denying that there is value in such tests, as in

other projective types. Very few seem to be willing to trust the Rorschach to stand alone, however. Would it not be more profitable to work on other testing means, such as the situational tests, or the personality factor inventories, and relegate the projective test to a position as an accessory test? Such a policy seems worthy of consideration.

Just as the use of projective tests suggests a connection between the subconscious, the personality, and the propensity for fatigue, so some of the other research in measurement suggests a connection with other parts of the study of psychology. D. Russell Davis, for example, found a link between fatigue and psychological drive theory.[33] In one of his studies, he showed how frustration or satiation each could create anxiety, which in turn could cause work impairment and tiredness. The implication is that the secret to prediction may lie in measuring degrees of frustration or satiation. Feffer and Phillips, in another study, developed the hypothesis, related to motivation theory, that normal subjects with high social attainment perform better than others who do not "mix" as well.[34] This hypothesis, incidentally, was verified, as they found evidence to support the implication that marked social inadequacy frequently denoted pronounced inability to cope with stress.

The real importance of the studies into the "objective" measurement of fatigue seems to lie in the close relationship to "prediction". "Prediction", of course, is the first step to "control". Of all the measuring methods available, the most valuable from a predictive point of view, is psychiatric screening. Unfortunately, this method is expensive in time, both for subjects and the limited number of psychiatrists available, and, of course, as a corollary, in money. Perhaps the answer may lie in more training in psychiatric technique for "general medical practitioners"; perhaps the answer lies in "downgrading" the screening so that it can be administered by the less highly trained psychologists. Certainly, the

benefits which might accrue from a regular program of psychiatric testing should not be "written off" as unattainable, for they are too valuable. A study prepared by Holtzman and Bitterman gives ample testimony to this fact.[35] Their description of how potential flying personnel are screened, and how emotional conditions which are precipitated by an anticipation of combat and the actual stress of combat, may be measured and predicted, seems to have considerable value for a program of screening for other personnel.

Assuming, however, that such a program is infeasible in the short-run situation, it becomes important to find some other method which might be employed in conjunction with the situational testing and the projective testing mentioned heretofore. Some very valuable tools have been developed in the guise of "paper and pencil" tests. Such a series of tests is the Minnesota Multiphasic Personnel Inventory. Eschenbach and Duprea provide a good example of the use of one such test.[36] They administered the test to 22 males in what they termed a "realistic survival situation" containing conditions of fatigue, stress, and anxiety. They found definite predictable trends on the various scales and high test retest reliability. This is certainly an encouraging report. Good "prediction" may be available at relatively low cost.

One general trend seems to pervade all the work in "prediction"; it is so important that it merits being singled out for special emphasis. This is the fact that one test alone is not enough. In a 1952 study, for example, Deese and Lazarus used Rorschachs, subjective ratings, observations of tremor, perspiration, and degree of verbalization, as well as measuring deterioration in performance, in an experiment predicting and measuring the effects of stress.[37] Brožek and Taylor concluded that a combination of a battery of tests of motor functions and physical indices of ability to perform hard physical work, measured deterioration in the presence of stress better than either method by itself, and, at the same

time, provided a more meaningful method to determine fitness.[38] One development from the multi-measure concept has been the use of factorial analysis. Holtzman and Bitterman performed such a study.[39] They found it useful to use ratings of personality, ratings of officer aptitude, objective and subjective personality tests, physiological measures of performance under stressful circumstances, galvanic skin response perceptual tests, as well as the analysis of urinary components, in studying Air Force R.O.T.C. cadets in an attempt to predict reactions to stress. The trend to multiple measurements enables better prediction, since many of the inaccuracies "wash out", and a more accurate analysis remains.

The area of measurement and prediction of fatigue is dynamic. Methodology and procedures are becoming smoother and more accurate with the passage of each day. There can be no doubt that, today, if such a program were desired, prospective commanding officers could be placed in controlled experimental stress situations in which they could be required to make decisions much the same as those which they would have to make on board ship. Furthermore, their reactions might be predicted from available tests, and measured by available measures of all three categories--physiological, subjective, and objective. It is possible that the results would not be meaningful, since even a realistic laboratory situation could not achieve the finality of the "real" thing. It seems likely, however, that those who "flunk" in the laboratory are the ones most likely to "flunk" in the actual situation. It somehow seems better to eliminate the "risks", even in the face of the nagging possibility that some of the officers eliminated might possibly not have failed under actual stress. It must be admitted that this does create a dilemma--how to treat those officers who "flunk" the stress test. It seems, however, that there are many positions in the service where such persons could serve with honor; it seems the blow to individual "ego" is hardly so serious as to warrant placing many lives in possible jeopardy. It is not inconceivable that a system could

be devised, where failure on such a test would carry no professional stigma. Perhaps the Navy is not ready for this yet. It seems that with a relatively small "educational" effort, there might be a very big pay-off. It certainly seems that an examination system is well worth this price.

FOOTNOTES

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CHAPTER IV

THE ALLEVIATION AND CONTROL OF FATIGUE

In many respects, this section, concerning the alleviation and control of fatigue, is the most interesting one of this study. One reason for this is that it is an area of positive approach, while the other areas seemed either neutral or negative. A second reason is that this is a highly practical area, while earlier areas considered situations which were difficult to visualize in other than the laboratory environment. Third, this area seems much closer, much more personal, that the others. It is almost as if this area were composed strictly of "first" and "second person" information, and the other areas were "third person."

This section of the study has been subdivided into three parts. In the first, various studies which bear on alleviating and controlling fatigue are reviewed and discussed; in the second, applications and findings are discussed and recommendations made from the standpoint of the individual Naval officer; in the final part, policy and procedural recommendations are suggested for the Navy as a whole. This part also includes the general conclusions gathered from the entire study.

Perhaps the best known portion of the research into alleviation is that part which has been concerned with physical fitness. Physical fitness, of course, received a great boost through the positive interest and intensive campaign of the late President, and the adoption of compulsory standards of physical fitness throughout the armed services. Interestingly enough, completely apart from this program, the research into fatigue has disclosed that improved physical fitness means improved capability to resist stress. Where the discrepancy between the fatigue research and the fitness program seems to lie is in <u>what</u> constitutes physical fitness,

and how it should be measured. There is some doubt whether a prescribed number of particular muscle exercises performed once every ninety days is a good measure of the type of fitness required of our Naval officers. It is beyond the scope of this paper to develop such a measure; the intent here is merely to doubt it, and suggest that a much more meaningful program and set of standards might be developed--especially for Naval officers.

Different researchers have emphasized different aspects of fitness; many of the results are interesting and enlightening as they suggest that some of our "common practices" might well be overhauled. One such study, performed by Simonson, Brožek, and Keys, examined the importance of particular diets to fitness [1] They performed a detailed study in which they examined comparatively the effects of no food, of a "standard" meal, of a high-fat meal, and of a low-carbohydrate meal, each of which meals contained about 1300 calories, on visual performance under stress. The subjects--six young men--were measured by means of blinking rates and opthalmological tests, and subjective questionnaires. The experimenters determined that none of these meals might be considered optimal for all conditions. They did find, however, that visual performance after the carbohydrate meal was poorest, but subjective physical discomfort least. For best visual performance, alone, the "standard" and high-fat meal are the best. Perhaps diet should be governed by the anticipated stress rather than vanity or unreliable appetite!

Another interesting aspect of the research concerned with fitness, has been the examination of the relative duration of work periods to determine the timing and optimal length of "breaks". In one study concerned with this problem, Griffith, Kerr, Mayo, and Topal examined 379 manual, office, and supervisory employees with a subjective tear-ballot type of test to

determine relative feelings of weariness and restfulness during an eight-hour working day.[2] Uniformly, their subjects reported maximum fatigue during the fourth and eighth hour. This seems to suggest that the best time for a "break" would be in the fourth hour. In a later study, however, Bornemann suggested a different solution.[3] He suggested that 5 to 10 minute pauses were more valuable than long breaks in inducing rapid recovery from fatigue. He also recognized a cumulative effect. He hypothesized that during the course of the day, the "breaks" never completely restored the workers and he therefore concluded that lunch time might be better timed two-thirds of the way through the "eight hour day" than at the mid-point. Although destroyers at sea do not observe "eight hour days", it might prove most enlightening to set up an underway schedule using Bornemann's findings.

The idea of "breaks" is pursued in greater detail by Schmidtke.[4] In an analysis of the problems encountered in moderately heavy, as well as light, work, he found that at a set tempo of operations, he could actually cause "fatigue" to diminish by using 2 to 8 minute "breaks"! This, of course, is only a temporary phenomenon, and will disappear over time, but it points up most lucidly what can be accomplished through careful timing and work measurements. The crux of this study was that job efficiency for all could be improved considerably by the scientific application of "breaks".

Another very interesting part of the alleviation research has been concerned with the analysis of bodily reactions to stress, and the use of various drugs, either in treatments to improve resistance, or as restoratives. One such pharmacological study was performed in 1952 by Heim.[5] His most significant finding was that fatigued muscle suffered a deficiency in Vitamin C. This caused him to conclude that the "impulse" of fatigue was "switched off" at the lower nerve centers, and that when these impulses reached the higher centers, conscious fatigue would appear. Based on

this hypothesis, Heim considered that some "fatigues" might be successfully treated by analgesics and light hypnotics. Much subsequent research has been devoted to attempts to use such drugs in this fashion. In an interesting study published by two Italians, Caprini and Melotti, a stimulating drug was tested as a possible alleviator for "psychophysical" fatigue.[6] They administered coramina-glucosio in tablets to a large number of truck drivers to counteract fatigue; they found that, for the majority, efficiency was increased without unpleasant after affects.

In another of the "drug" studies, Seashore and Ivy explored the use of analeptic drugs as restorative agents in relieving fatigue.[7] In a comparative study, in which they examined the effectiveness of caffeine sodium benzoate, benzedrine sulfate, and desoxyephedrine hydrochloride, in combating fatigue in both civilian and military work situations, they made some rather significant findings. For one thing, they found that, for all three drugs, deleterious side-effects were practically non-existent. Of the three, they found benzedrine the most effective, caffeine the most desirable from a subjective viewpoint, but of little benefit for sensory improvement, and desoxyephedrine the most subjectively unpleasant, but of significant benefit for sensory improvement. This study may sound the "death knell" for that horror of all destroyer wardroom horrors--that pot of coffee, made at midnight which has been "thoughtfully" left simmering all night for the 04-08 watch and the navigator!

Another drug experiment was conducted by Bujas, Vidaček, and Vodanović in 1960 to investigate the effect of stimulating drugs on work output of a physical type.[8] In this study, the authors compared phenamine, ritaline, preludin, and veronal. They found that stimulating drugs had almost no positive effect on persons who were physically "fresh" and were well motivated, and that these drugs did not seem to be of much assistance when the individuals were engaged in sub-maximal physical

efforts. The only situation in which they noted a positive effect was in "all-out" physical effort. Parenthetically, they also noted that the use of the stimulator did make the subjects "feel" less tired, and that using them did not at all slow down the physical processes of restitution after fatigue.

In another recent study, Evans and Caldwell examined the results of a series of tests in which magnesium salts of diaspartic acid were evaluated as restoratives.[9] The principal results of the experiments, which were conducted on highly motivated persons, was the disclosure that the apartates apparently did not have any effect whatsoever on performance, but that they did cause the subjects to "feel" better than they did after administration of placebos.

With the recent emphasis on sleep deprivation in the stress research, there has been an increased interest in the use of drugs to alleviate some of the effects of this stressor. In a 1959 study, Komitsky, Mersky, Kessler, and Dorff examined dextroamphetamine as a possible alleviating agent of some of these, with very interesting results.[10] In the course of the study, they discovered that the amount of stress used (44-68 hours) produced a wide variety of results in the subjects tested, dependent on their individual characteristics, and that only those who were least affected by the sleep loss received any benefit from the drug at all. For these few, they found dextroamphetamine did cause the subjects to return to a non-sleep deprived level as far as mental lapse type of errors were concerned; in other areas, even in these subjects, they found little if any noticeable alleviation of undesirable effects.

In general the results of drug research seem mixed, "salted" with encouraging developments and "peppered" with discouraging set-backs. It seems to be a field of great promise, however, and as various aspects of fatigue are more accurately isolated, it should become easier to find drugs to counter them. At any rate, this is a part of the research where

there seems to be a dynamic opportunity for significant future breakthrough.

One of the most interesting and important of all the aspects concerned with alleviation is what is familiarly known as "man-machine" research. Basically, this is concerned with considering the man and machine as integral parts of the same system, and, in effect, building the machine as if the man were one of the parts. Such a procedure recognizes the "costs" of excess human motion and work just as much as the more commonly observed mechanical inefficiencies. Many ramifications of this theme are possible. In one early study by Schulte, for example, the author concerned himself mainly with the design of handles, hand-wheels, cranks, and adjustable work chairs.[11] In this study, he examined anatomical considerations as well as physiological studies of work capacity. Considerations included the adaptation of bodily strength to mechanical loads, selecting the correct muscle system, using the simplest bodily movement, avoiding static muscular activity, insuring free blood circulation, providing frequent rest pauses, and avoiding over-extended work postures. The implications for shipboard use are somewhat subtle, because the problems of physical fatigue encountered by the manual worker are not those that beset the decision making commanding officer, as shown before. It is well to remember, however, that the careful design of such simple shipboard items as desks and chairs may greatly affect a decision maker. Poorly designed furniture might critically lower resistance to stress! This conclusion may not be as far-fetched as it might seem at first examination. To prove the import, time study information would have to be obtained. It seems safe to hypothesize, however, that such studies would show that most commanding officers spend a great deal of time in chairs at desks.

In many cases, the research into "effects" or "measurement" has suggested the required alleviatory measures so completely that further development in this section seems apocryphal. Observations of fatigue problems in the tropics as opposed to temperate working conditions, for example, suggest the need for employing air-conditioning equipment to lessen the effects of the stress. Nevertheless, a variety of studies have been conducted over a long period of time, investigating the proper thermal conditions for maximum output (minimum fatigue). One particular study, by Thomas Bedford, summarized the previous efforts, and set forth some valuable information.[12] For one thing, he presented a very useful subjective concept which he called "thermal comfort".

> In Great Britain, in the winter months, people engaged on light industrial tasks and wearing normal indoor clothing are likely to be comfortable when the air temperature is about 65°F. . . . Unless the temperature of a factory is automatically controlled variations will occur, and these may be considerable. It is therefore desirable to know the limits within which the temperature should be maintained. Analysis of some 3,000 observations on people doing light work showed that so long as the air temperature lay between 60° and 68°F, . . . at least 70 per cent of the persons questioned were quite satisfied with the degree of warmth provided, and never more than 14 per cent suffered actual discomfort. . . . Such a range of temperatures can suitably be regarded as a comfort zone.[13]

Bedford also discussed temperature with regard to working efficiency, accident liability, and finally, with health. In a very engaging summary in which he "locked horns" with the problem of controlling temperature in industry, he cited an example of lightly clad soldiers marching in extreme heat with relative ease under certain wind conditions, who collapsed when the temperature was changed by an amount less than 2 degrees! He concluded as follows:

> During the war it was recommended by the Royal Naval Personnel Research Committee that in H. M. ships the effective temperature, adjusted for radiation, should if possible

> be kept below 80°F. With calm air and an air temperature of 90°F this represents a wet-bulb temperature of 72°F. It is a reasonable conclusion that for active, yet not heavy, work when people must be clothed the wet bulb temperature should not exceed about 72°F.[14]

This seems to provide a good target for our own ships as well.

In some respects, "subjective" fatigue seems quite close to alleviation. If a person "feels" tired, it would seem rather simple to progress to the logical next step--doing something about it. The problem is not simple, however, as has been demonstrated hereinbefore. Neither are the "feelings" an accurate measure of fatigue, nor are they differentiators of the stress that has caused the fatigue. Some research, then, had been devoted to the alleviation of the "subjective" part of fatigue, on the assumption that this is a large and critical area. The approach of the scientist, characteristically, depends on his discipline. Brouha, the noted physiologist, for example, stressed the importance of physical fitness.[15] By careful selection of physically-fit workers, by making working environment optimal, and by using machines designed for maximum efficiency, while causing the operator the minimum possible stress under this constraint, he believed fatigue could be kept at a minimum. On the other hand, Hornstra, an eminent psychologist, stated that except for muscular fatigue, he considered fatigue to be almost entirely emotional.[16] He would treat fatigue, thus, as a psychosomatic expression of partial frustration which was part of a reversible process. Furthermore, he suggested that the worker's need satisfactions must be examined in totality to see if his needs were being satisfied as a result of the task performance. This was to avoid the tendency to examine the actual task to see if it was congenial and need-gratifying. The distinction seems well taken. A man might become quite gratified if he received a large remuneration for collecting garbage, even though he received no gratification whatsoever from the job itself.

One familiar approach to the problem of alleviating "subjective" fatigue is through the use of music. McGehee and Gardner, in a very interesting study, examined the use of music in industry.[17] They studied production on a highly complicated task on days when music was played, and compared it with performance on days when music was not played. They found no significant change in production--a fact which disturbed them a great deal, and caused them to launch into a very complex explanation involving long established goals and counter-balancing effects. What is significant about the study with regard to this report is that music apparently made the workers "feel" better. 86 per cent, for example thought that music gave them a "lift" when they were tired; 74 per cent allowed that music in the morning made them feel like coming to work; 82 per cent said that if they came in feeling bad, music helped them feel better; 73 per cent stated that music kept the job from "getting on their nerves"; 73 per cent considered music helped to break the monotony; 77 per cent felt that they had more "pep" with music. On the negative side, only 4 per cent considered music interfered with their work, although an additional 21 per cent said that they had no opinion one way or the other on this question; 6 per cent felt that music made them nervous, while 19 per cent stated that they were unable to tell whether it did or not. These data seem conclusive; music can have a real value in the alleviation of "subjective" fatigue.

One other approach to the individual fatigue problem which seems worthy of mention is the development of a "portable alertness indicator", which was thoroughly discussed and explained in a study by the noted psychologist and educator, John L. Kennedy.[18] The background of the project as described by Kennedy is almost as interesting as the project, itself:

> During the closing phases of World War II, it was reported that German scientists had been working on an automatic device for alerting personnel, such as pilots when they were in a dangerous condition of drowsiness or fatigue. The physiologist Kornmuller, it was further stated, had developed a portable, light weight device for using brain-waves as a physiological indicator of the alertness condition of the subject, particularly the slowing of alpha frequency which occurs when the subject is drowsy. The practical device was so constructed that an alarm or alerting signal would be turned on by the change in frequency of the alpha rhythm and, I presume, would be turned off when the alpha rhythm returned to its normal frequency of around 10 cycles/sec.[19]

Because of this report, the Special Devices Center, Office of Naval Research, working with Tufts College, Department of Psychology, evaluated the feasibility of the idea. They built a successful model which could be used on board ship, but even the optimistic Kennedy was forced to admit that:

> We have conducted some field tests with the Portable Alertness Indicator. These, in general, have indicated that, if you send a specially-trained technician out with the equipment, it will perform with about the same characteristics as the laboratory model. But it would be impossible, at the present stage of development, to just turn the device over to an untrained person to operate, such as is possible, for example, with an automobile radio.[20]

Kennedy concluded that the idea was not practicable. He indicated that perhaps the problem was not so serious as to warrant such a complicated contraption. He considered that other indicators might provide better measuring, and the administration of drugs such as benzedrine the required positive alleviation. The idea of the portable indicator remains intriguing; perhaps improved technology and refined procedures can make it practicable.

In general, the problem of alleviation seems best handled from a multi-sided approach. In a 1962 study, Hackl suggested that a positive program of physical examinations with particular attention to different

body types was important, as well as scientifically spaced rest periods.[21] He considered the problem social as well as biological In his "practical analysis", Kennedy suggested a more whimsical combination:

> The last problem I wish to raise has to do with alternative ways of handling the alertness problem practically. There are other available physiological indicators of the condition of the body, such as the Oximeter, which uses a photo-electric pick-up based on transmission of light through the lobe of the ear and measures the amount of oxygen in the blood by the change in colour of the blood; the electrocardiogram; the galvanic skin response, etc. One of these or a combination of these might provide a more positive indication. There is an old patent on a simple alertness monitor--namely a harness for positioning a spike under the subject's jaw. When his head falls down, his chin is impaled on the spike and he is alerted very positively![22]

More useful, indeed, is the program which Gärtner sets forth in a 1952 study.[23] He suggested that an individual should have a good home location, where he can find restful conditions, preferably about 30 minutes traveling time from the site of his work. He suggested that mental workers should perform in some sort of physical activity, although a work associated hobby is also considered desirable. He suggested that excessive drinking and smoking should be avoided since they hinder rest, but considered a little alcohol beneficial since it promotes sleep. He suggested that rest periods of up to 30 minutes during the day might be very beneficial, but he cautioned that larger periods should be avoided since they might interfere with night's sleep. This study provides valuable insight into the problem to be discussed in the second part of this chapter--what can the individual destroyer commanding officer do to lessen the effects of stress.

Obviously, all of Gärtner's suggestions are not applicable or adaptable to the work environment of a destroyer at sea, but many are

worth considering. One of these is the question of habitat. On a destroyer, the commanding officer normally "lives" with his office-- since only in the newer ships does he have more than one room. (Most of the old destroyers have "sea cabins" in the bridge area, but these are so cramped that their use is almost completely functional-- sleeping, dressing, and using the toilet facilities.) To compensate for this situation, then, the destroyer commanding officer should make a determined effort, at a certain point in the day, to put aside his administrative work and not consider it any further that day. This requires a fairly firm schedule, and high resolve, because there always seems to be administrative work pending. The "break", however, will probably result in higher output. This policy, of course, must be flexible; deadlines are deadlines, especially in the military, but the commanding officer should not surrender easily to the temptation to violate the schedule. A second matter has to do with physical exercise. No matter what his age, and regardless of whether he is required by regulation to perform physical fitness test exercises or not, he should endeavor to participate in a regularly scheduled daily program of physical exercise. It must be scheduled or it will not be accomplished. It must be regular to preclude undue and sudden strain. It must be physical, because the work of the destroyer commanding officer is essentially mental. Recommendations for cutting smoking down, or lowering consumption of alcoholic beverages are not so easily incorporated. If fear of cancer will not stop persons from smoking, certainly the threat of sleeplessness will not greatly disturb them. The question of liquor on board ship is old and much discussed; this paper is not the proper forum for a continuation of that discussion. Suffice it to say that the question of liquor on board ship will not be decided on the basis of the fact that an occasional "dram" at a well chosen moment might help the captain get some sleep. (It might be contended that U.S. ships, contrary to popular belief, do carry some liquor on board,

which is normally controlled in the same manner as the medicinal drugs and narcotics. There is, however, very little of this, and consequently, it is usually dispensed only in conditions of extreme exposure, or the like. If the Captain wants a drink to help him sleep, he would have to jump over the side.) Of all the suggestions proffered the proposal about 30 minute naps seems the one most likely to achieve instant success. It does not have to contend either with ingrown habit or Navy Regulations to gain acceptance. In fact, it is, undoubtedly, quite widely practiced. It is one of those rare practices, which is highly enjoyable, and scientifically sound.

Many other applications can be taken from the research. It might, for example, be quite sensible to cut back personal coffee consumption, and munch benzedrine tablets instead, when that "little extra" resistance to fatigue is required. Most destroyers now have a capability to provide music throughout the ship; it might be worthwhile to provide music designed to improve mental efficiency through this medium. (This recommendation is qualified because what is one person's music is another person's noise, and frequently the opposite poles on this continuum are occupied by the 40 year old commanding officer, and the 19 year old radioman, who twists the dial.) Thermal control and a "comfort zone" make good sense; ships are being constructed or modified, more and more, in a manner to facilitate this. All of these matters seem trivial or obvious when exposed singly; in sum, however, they become quite important. More significant than these, however, is the one prerequisite on which any meaningful individual "attack" on fatigue must be based. Every officer in command should have a thorough knowledge of the types of stress to which his system might be subjected, and an equally thorough knowledge of the characteristics of the resultant fatigue. Even more important, the commanding officer should have a well developed knowledge of his own and his subordinate's reactions to the various stressors, singly and in combination.

This is a large order. No one can know "everything", but if the commanding officer is examined regularly, and if the results are made known to him, he can find out much. By observation of subordinates, and correlation with test results, he can find out much more. This is the beginning of an individual approach to fatigue control. It leads quite naturally into the final part of this section--the discussion of the proper role of the Navy Department in the alleviation and control of fatigue.

Any comprehensive program for the Navy Department in the control and alleviation of fatigue must logically be centered about a program of testing of reactions to stress, and examining decisions made under various degrees and types of fatigue. As demonstrated in this report, there are many tests available for use. A feasible program, for example, might consist of a battery of "paper and pencil" tests, including Rorschach and thematic aperception tests, and physiological and psychological measurements of reaction to mild stress, as part of the annual physical examination now conducted on all officers--or as an adjunct to the quarterly physical fitness tests. (The first alternative seems preferable because the fitness tests terminate at age 40, and this is the "prime-of-life" for the Navy decision-maker.) These tests should be for all line officers--not merely commanding officers. For prospective commanding officers, a minimum of three days of extensive situational stress testing should be conducted. In most of our larger operating ports there are already in existence well equipped, realistic "mock-ups", in which operational situations can be very elaborately duplicated. Turning such "mock-ups" into laboratories would require almost no cost. (The costs envisioned are personnel costs, and costs for such measuring equipment as is desired.) For example, in such a setting, a commanding officer, under stress of 48 hours sleep deprivation might be required to make an in extremis emergency ship-handling decision. In these days of computers and complicated programs,

it is easy to imagine quite complicated and sophisticated embellishments. These are possible, but not necessary to achieve the desired ends. A series of 20 or 30 meaningful, simple situational problems should prove extremely informative. Most important, the results should be discussed with the officer examined. This type of testing would provide a solid base for any proposed program; it would provide current "feed-back" of some worth--a far cry from the results of psychological tests administered at induction time, and never further utilized.

A second area for Navy Department attention is the further development of the "man-machine" research. Much has already been accomplished along these lines. The operational equipment in the new destroyers is much more functionally distributed than in the old. All one has to do is to look into the Combat Information Center of an old destroyed before and after FRAM conversion to see the difference. Sometimes the application of "man-machine" ideas is so gradual that it is only noticeable over time. Sailormen consider deck to overhead heights "standard", yet, even the most landlubberly visitor to the U. S. S. CONSTITUTION will note that something has changed since that ship was built with her "'tween decks" of considerable less than 6 feet! "Man-machine" accommodations must be continuing; just as the physical characteristics of people change, so also do the uses to which shipboard equipment is put. The system must be continually up-dated.

Many other supplementary procedures should be adopted or continued in the battle against fatigue. Extensive background screening of officer candidate personnel--both psychological and physiological--seems worthwhile, and should be continued. An innovation to the fitness report in which the commanding officer would be required to evaluate

his subordinate officers under the headings of "reaction to stress" or "propensity to fatigue," might prove quite valuable--as much by forcing the reporting seniors to contemplate these problems as in the actual evaluation assigned. The establishment of some kind of a "peer-rating" system in this area might prove even more valuable as Robert Burns would attest:

> Oh wad some power the giftie gie us
> To see ourself as others see us!
> It wad frae monie a blunder, free us,
> An' foolish notion[24]

The greatest value of all might well accrue, however, to a comprehensive system of reports submitted by subordinates. Who better knows the leader than his followers? Admittedly, this system might prove difficult to put into use, but if properly used the information could be most valuable.

In closing this report it seems important to focus on its limitations and its broader purpose. This has been a report based almost exclusively on the results of research directed at other professions, other disciplines, other purposes. Some of the conclusions and observations may, therefore, and quite properly, be vulnerable to attack. The only way to test the conclusions and observations is in the "laboratory." Since this is beyond the capabilities of the writer in scholarship, time, and money, it will have to be left to some future student of the problem. There seems no doubt, however, that stress can exact a heavy toll from the human system, and that this system, remarkable as it is in its defenses, inevitably must suffer. To simplify the significant to its minimum, if those effects can be lessened at all, it may be that at some time a fatal decision will not be made, a ship and many lives not lost. On the night of 26 April, 1952, the aircraft carrier WASP collided with the destroyer HOBSON in the north Atlantic.[25] 176 lives were lost. No

one knows just how much stress and fatigue had to do with that collision, but it is reasonable to assume that such factors were present. If a new system can prevent one such disaster, by insuring that the one person who will have to make the critical decision is better prepared to handle the "out of the ordinary", will not it be worth the price? It seems so.

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